REMARKS

Claims 1-14 and 16 are pending in this application. Claims 1-14 and 16 are rejected as follows: Claims 1-5, 11-14 and 16 are rejected under 35 U.S.C. §103(a) as being unpatentable over U.S. Patent Application No. US 2004/0064037 to Smith ("Smith") in view of *Digital Angiography Using a Matched Filter*, IEEE Transactions on Medical Imaging, Vol. MI-1, No. 1, July 1982, pp. 16-21 by Kruger *et al.* ("Kruger"); claims 6-9 are rejected under 35 U.S.C. §103(a) as being unpatentable over Smith in view of Kruger and further in view of U.S. Patent No. 6,718,055 to Suri ("Suri"). In view of the remarks presented herein, the Applicant respectfully traverses these rejections.

Rejections Under 35 U.S.C. §103(a)

Claims 1-14 and 16 are rejected as follows: Claims 1-5, 11-14 and 16 are rejected under 35 U.S.C. §103(a) as being unpatentable over Smith in view of Kruger and claims 6-9 are rejected under 35 U.S.C. §103(a) as being unpatentable over Smith in view of Kruger and further in view of Suri.

To establish a *prima facie* case of obviousness the Examiner has the burden of establishing that the teachings of more than one reference may be considered in combination provided one of ordinary skill in the art would combine the references in that way to solve the problem facing the inventor and that the combination of the cited references disclose every element of the pending claims. *KSR International Co. v. Teleflex Inc.* 127 S. Ct. 1727, 1734 (April 30, 2007). Applicants respectfully submit that the Examiner has not met that burden.

As noted by the Examiner, Smith fails to disclose each and every element of independent claims 1, 14 and 16. Specifically, Smith fails to disclose at least the following elements:

(i) measuring a quality of the registration of the time-separated images;

(ii) calculating a level of agreement between the measured temporal behaviour and the expected temporal behaviour;

(iii) determining a measure of the quality of the registration from the calculated level of agreement;

(iv) wherein the measure of quality of registration indicates that registration quality is poorer when the calculated level of agreement is lower.

Furthermore, even assuming *arguendo* that the motivation to combine the teachings of Smith in view of Kruger is proper, Kruger still fails to cure the deficiency in the teachings of Smith.

Kruger is concerned with obtaining a high quality x-ray image of arteries or veins by taking a series of time-separated x-ray images as a contrast agent flows through the blood vessels. The aim is to maximize the signal from the arteries or veins while removing stationery background anatomy.

A simple way to achieve this is to use "*subtraction*" in which an image taken when there is a maximum amount of contrast agent in the blood vessels is subtracted from an image when there is no contrast agent present. In the ideal case this would leave an image of just the blood vessels. Because such an ideal is not possible in reality, Kruger proposes a more sophisticated approach than the simple subtraction of two images. This more sophisticated approach involves a linear combination of several discrete images acquired during flow of contrast agent using different weighting coefficients for the different discrete images. Kruger notes at page 17, col. 1, lines 7 to 16 that a simple subtraction can be regarded as performing a linear combination in which the image having maximum contrast has a weight of 1, the image with minimum contrast has a weight of –1 and all other images have a weight of 0. The aim in Kruger is to derive an optimum set of weights that will maximize the signal to noise ratio of the blood vessels containing contrast agent, and minimize the background. It achieves this by deriving the weights retrospectively, i.e. by examining the time series images after they have all been acquired. This general aim is explained at page 17, col. 1, lines 7 to 16 which say:

> "*The purpose of this paper is to show that for a given contrast dilution curve and for a set of discrete images (acquired during the flow of contrast material through an area of interest), an optimum filter function exists. This filter is*

> *optimum in the sense that background anatomy is cancelled and the signal to noise ratio (Sin) associated with opacified vasculature is maximised given the set of initial images. This filter is a type of matched filter with a characteristic impulse response which can be derived retrospectively from the acquired image set*"

Thus the output of the method of Kruger is the result of linearly combining several images with certain weights as defined by Equation (4)', namely:

$$s'[N] = \sum_{j=0}^{N} k_j s[j]$$

The theory section bridging pages 17 and 18 of Kruger results in a formula for selecting the weights k_i as defined by equation (17):

$$k_i = s[i] - \bar{s}$$

In essence, the weight for each image is the value of the signal $s[i]$ minus the average of s over the whole time series of images. Thus the "matched filter" of Kruger is actually an algorithm that adds together the time-series of images with the required weights. The effect is to enhance those areas of the image that vary in brightness while de-emphasizing those areas of image whose contrast does not vary. This is because the signal (as a function of time) for a part of the image whose contrast is not varying much will, of course, stay close to its average value, and thus the weights k (defined as the signal minus the average) will be small. On the other hand, for an area where the contrast varies greatly from its average through the time series, some of the weights will be large.

Kruger notes in Section V that the use of this "matched filter" naturally results in a reduced sensitivity to sudden patient motion. There is no indication in Kruger that any other measures are taken to account for patient motion. In particular it is important to note that there is no image registration process. Thus there is no step in Kruger of shifting the various time-separated images in order to try to align corresponding physical

features. Again, Kruger does not include such a registration step. Instead, Kruger simply notes the inherent insensitivity to motion in his matched filtering method.

In Section VI Kruger discusses the image variations that result from both noise and patient motion, both of which are undesirable. First, Kruger notes that the use of a large window in the image means that the effects of image noise are reduced (presumably by simple averaging over a lot of pixels). Kruger also notes that by looking at the "*integrated image variation within a window comprising a large number of pixels*", only motion at the boundaries of the window would tend to make a result of the integration change. Given that one is summing over the whole window, patient motion in the center does not matter since it does not alter the result of the sum. Again, this section of Kruger does not disclose the use of any registration process to account for patient motion.

In the section on page 20, col. 2, lines 25 to the end, Kruger discusses the problem that the curve of contrast variation averaged over a window is associated with all blood vessels in the window, and these may include arteries and veins that have "*large flow differentials*". Thus, in this section, Kruger is not discussing the effect of patient movement, but instead the fact that different types of blood vessels within the image may show variations in blood flow at different times. For example, one would expect the contrast of the arteries to increase and then decrease before one sees a corresponding increase and decrease in the contrast of the veins. Kruger therefore proposes that one could use two different filters (i.e. two different sets of weights k_i), one matched to the variation in contrast of the arteries and one matched to the variation in contrast in the veins. Applying one filter would tend to enhance the arteries compared to background and veins, and the other would tend to enhance the veins compared to arteries and background. This is what is meant by the sentence at the end of page 20 which says:

> "*curve-fitting routines could then be used to form two filters, one matched to arterial opacification, the other matched to venus opacification*"

This section of Kruger is utilizing knowledge of the underlying physiology in the images to provide matched filters (sets of weights) that can pick out particular physiological features. There is no suggestion of measuring the quality of the images in any way, still

less the quality of the image registration step (there being no image registration step in Kruger).

Therefore Kruger is proposing a method in which a plurality of time separated images are added together with different weights *k*. The weights are calculated by examining the signal variation through the time series (i.e. retrospectively), so as to enhance the desired image features (arteries and veins – whose brightness varies) and to eliminate background (whose brightness is steady). The method inherently has a reduced sensitivity to patient motion and to image noise. There is no step of registering the different time separated images together and there is no step of measuring the quality of registration. Thus there is no concept in Kruger that a measure of registration quality could be obtained by comparing expected temporal variation to actual temporal variation.

Thus referring to the features of claim 1 which the Examiner indicated are not present in Smith:

I Kruger does not "*calculate a level of agreement between the measured temporal behaviour and the expected temporal behaviour*". There is no such calculation in Kruger. Kruger page 20, col. 2, refers to the use of two different filters "*in those situations where obvious flow differences occur*" between different vessels in the window. But there is no calculation of a level of agreement between an expected curve and a measured curve. Kruger is talking here about a user observation that there are flow differences between arteries and veins, and thus that a single filter needs to be replaced by two filters. There is no calculation of a level of agreement.

II Kruger does not determine "*a measure of the quality of the registration of the time separated images from said time calculated level of agreement*". In Kruger there is no registration at all. Thus there is no possible way in which Kruger can be calculating a measure of the quality of a registration step that is not performed. Further because registration is not performed in Kruger there can be no suggestion from Kruger that any temporal agreement is indicative of such quality.

III Kruger does not indicate that registration quality can be regarded as poorer if the calculated level of agreement between measured and observed temporal variation is low. Kruger does not recognize any registration step or any measure of quality in such registration. Kruger is only interested in applying a filter that enhances arteries or veins against background. There is no suggestion in Kruger of moving images relative to each other in order to align physiological features.

> Further, there is no suggestion in Kruger that the measure of quality of this alignment can be derived from the temporal behaviour of the imaged regions.

In paragraph 12 of the Office Action the Examiner made of record two further prior art documents namely Meijering *et al.* and Faber *et al.* The Applicant notes that Meijering is a review paper indicating methods used in the field to correct for motion correction in angiography imaging. The paper cited Kruger as using various filters. Note registration is not being performed. Later in the paper, post-processing registration methods are discussed, but they do not use the dilution curves as a measure of quality in the registration. Faber discusses the use of measuring a registration quality, for the purposes of registering medical images. However, there is no comparison to a model, and time activity curves are not mentioned.

For at least the reasons discussed above, the Applicant believes claim 1, as well as claims 2-13 depending therefrom, are allowable over the cited references. Accordingly, the Applicant respectfully requests the rejection of the pending claims be reconsidered and withdrawn.

Similarly, for as at least the reasons discussed above regarding claim 1, independent claims 14 and 16 are also allowable over the cited art. Accordingly, the Applicant kindly requests the rejections of independent claims 14 and 16 also be reconsidered and withdrawn.

Further, the teachings of Suri as cited by the Examiner in the rejection of dependent claims 6-9 do not cure the deficiency of the references cited regarding the independent claims 1, 14 and 16. Accordingly, for at least the aforementioned reasons, the Applicant requests that the rejection of dependent claims 6-9 in view of Suri be reconsidered and withdrawn.

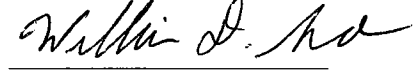
CONCLUSION

The Applicant believes that all claims presented in the present application are allowable over the cited prior art and respectfully requests reconsideration of the rejections and a notice of allowance to this effect.

Enclosed is the fee for a one-month extension of time. No additional fee is believed to be due with respect to filing this amendment. If any additional fees are due, or an overpayment has been made, please charge, or credit, our Deposit Account No. 11-0171 for such sum.

If the Examiner has any questions regarding the present application, the Examiner is cordially invited to contact Applicant's attorney at the telephone number provided below.

Respectfully submitted,



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